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CONVERSION OF ADVANCING LONGWALL TO RETREAT LONGWALL: A REVIEW REPORT

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CONVERSION OF ADVANCING LONGWALL TO RETREAT LONGWALL: A REVIEW REPORT

by

G.A. Haslett*

SUMMARY

Longwall retreat mining employing the latest technology can outstrip any other system in the fields of concentrated production and costs. The system has nevertheless many modifications that acknowledge site specific conditions. A review of the constraints on the system is given together with a number of panel layouts including some that utilize longwall advancing in conjunction with longwall retreating.

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CHANGEMENT DE LA MÉTHODE D'EXPLOITATION PAR GRANDES TAILLES CHASSANTES À LA MÉTHODE D'EXPLOITATION PAR LONGUES TAILLES RABATTANTES: COMPTE RENDU

par

G.A. Haslet*

RÉSUMÉ

La méthode d'exploitation par longues tailles rabattantes alliées à la technologie de pointe, est supérieure à toutes les autres méthodes d'exploitation quant au rendement et aux coûts. On a néanmoins modifié cette méthode de façon considérable en tenant compte des conditions particulières d'un chantier d'abattage. Ce rapport expose les problèmes que pose l'utilisation de la méthode et présente un nombre de schémas illustrant la disposition des chambres y compris celles où l'on emploie la méthode d'exploitation par longues tailles chassantes conjointement avec la méthode d'exploitation par longues tailles rabattantes.

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INTRODUCTION

The extent of development and the associated costs of development for longwall retreat mining, the logistics of supply for rapid development, improvements in technology with the more rapid formation of good quality gateside packs using quick setting cements and the consequent better stability of gate roads have all been factors that have influenced certain operators to persist with longwall advance mining.

Longwall retreat mining employing the latest technology can outstrip any other system in the field of concentrated production and costs. There are nevertheless, as with all systems, constraints which must be taken into account before the retreating system can be adopted.

CONSTRAINTS UPON LONGWALL RETREAT MINING

(i) RESOURCE RECOVERY

The use of single entry systems to block out retreat panels is not permissible by law in the U.S.A. Certain operators consider that development must contribute to the financial well being of the operation and that the development of retreat panels must not fall below the customary levels of productivity of conventional room and pillar operations.

To satisfy such a requirement, three, four, and even five entry drivages are sometimes standard. The loss in reserves from the adoption of a five entry system could be great as 45%.

(ii) GEOLOGICAL CONDITIONS

It is essential to longwall retreat mining that stable entry conditions prevail. The attainment of stability is dependent on a number of set parameters included in which are the depth of cover, the associated stress field, the strength of the enclosing floor and roof rocks, and the strength of the coal.

For any given set of such parameters the attainment of stability will depend on a correct selection of the width of any intervening pillars between panels, the width of the entries, and the degree and nature of support that is applied in the entries.

Of these variables width of entry is sensitive. The exceeding of a critical entry width by as little as 0.3 m has produced in some cases excessive floor heave. Support of the ribs to constrain the width of opening where coals are prone to sloughing is also essential.

(iii) RATE OF DEVELOPMENT

The speed of entry drivages for the continuity of output is critical in retreat longwall mining. The time for the equipping of a replacement face when a retreat panel has reached its life has been reduced from 60 days to as little as 3 to 4 days when careful preparations are made with the finishing line of a face, and the starting line of the replacement face. An additional cost that can be economically justified is the prior equipping of a replacement panel with a completed A.F.C.

The replacement entries for a longwall panel must therefore travel at a minimum rate in the order of three times the speed of the panel extraction rate. Any delays in the readiness of replacement faces has in general a greater negative impact on operation with retreating longwall systems.

(iv) ENTRY CONDITIONS

Sound entry conditions must prevail with longwall retreat mining. Attention must therefore be paid to the following two points:

1. Where multiple entries are used, the design parameters should ensure the stability of the pillars between adjacent panels and should similarly ensure that the entries that are reused as returns are free from major damage from preceding panels.
2. Time dependent deformation also plays a role in determining the life of panels in longwall retreat mining. Optimum panel lengths should acknowledge this parameter and secure some benefit, if possible, in the reduction in the frequency of transferring heavy powered supports from panel to panel.

(v) SEAM HEIGHTS

There is an upper limit of approximately 3.5 m for single liftsystems operating either longwall advancing or longwall retreating. This height is governed by the physical size and weight; and therefore, the stability of a powered support.

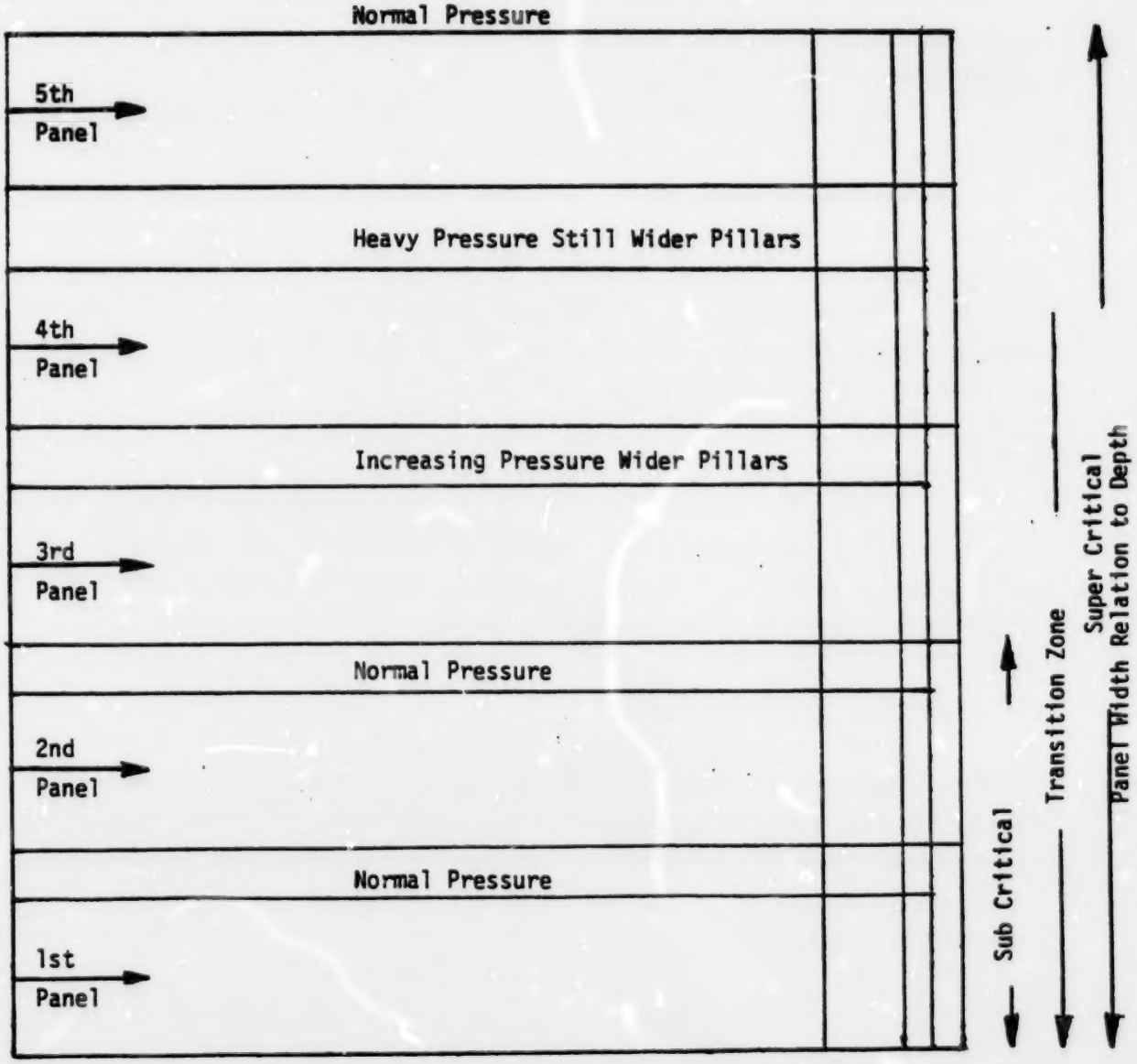

Fig. 1 - Starting conditions with no previous mining in the area.

Evidently there is no lower limit for the operation of longwall advancing as operations in the past have been conducted at seam heights as little as 0.36m. Longwall retreating has been practised with coal ploughs at heights as low as 1 m. where there appears to be justification for recovery of the reserves. The use of coal plough predated the buttock shearer, the advent of which might stimulate further interest in longwall retreating at height ranges down to 1 m.

Seam height is also an important parameter with respect to entry conditions. A seam height that does not require the removal of any roof or floor to secure adequate entry clearances for the life of the longwall retreat panel does not constrain the operation of longwall retreat mining. At approximately 1.5 m height constraint becomes evident and consideration has to be given to geological and time dependent deformation to determine whether either part of the roof or part of the floor, or both, will require removal to ensure suitable entry clearance.

(vi) SUBSIDENCE

Surface damage effects do not have to be considered where the workings are under the seabed. Restrictions on panel widths are necessary however to reduce tensile strains to acceptable levels that will secure safety from the ingress of the sea into the mine.

(vii) STARTING CONDITIONS

The initial layout of the panels (Refer Fig. 1) must have regard to critical lengths and critical widths that apply for the depths of working. When designing for the layout of panels, adjustments to pillar dimensions from standard may be necessary, or alternatively special additional support measures might need to be applied until the widths of the extracted panels become supercritical.

CONVERSION PANEL LAYOUTS (ADVANCING TO RETREATING)

The number of variations and combinations possible is only limited by the ingenuity of the mine planner. The following examples are intended to give the reader a range of possibilities to stimulate thought. No attempt has been made to address site specific problems that frequently restrict mine

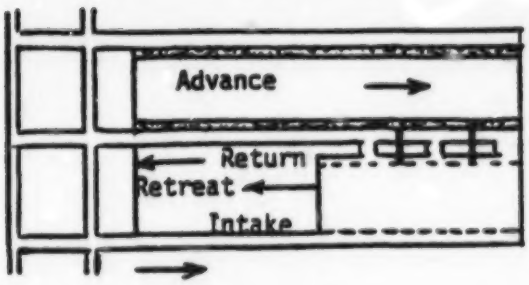

Fig. 2 - Two panel system

(1 Retreat)

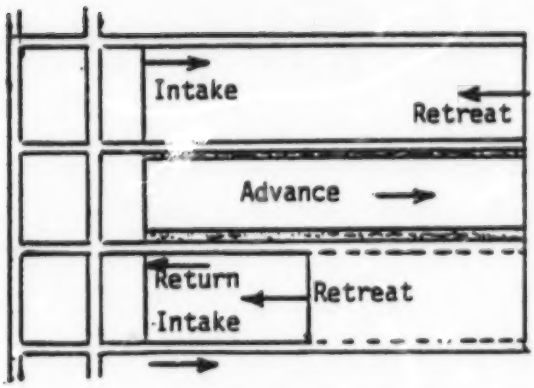

Fig. 3- Three panel system

(2 Retreat)

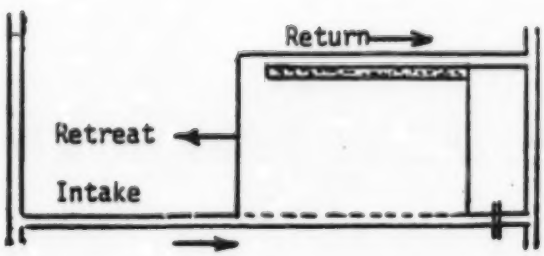

Fig. 4 - 'Z' system

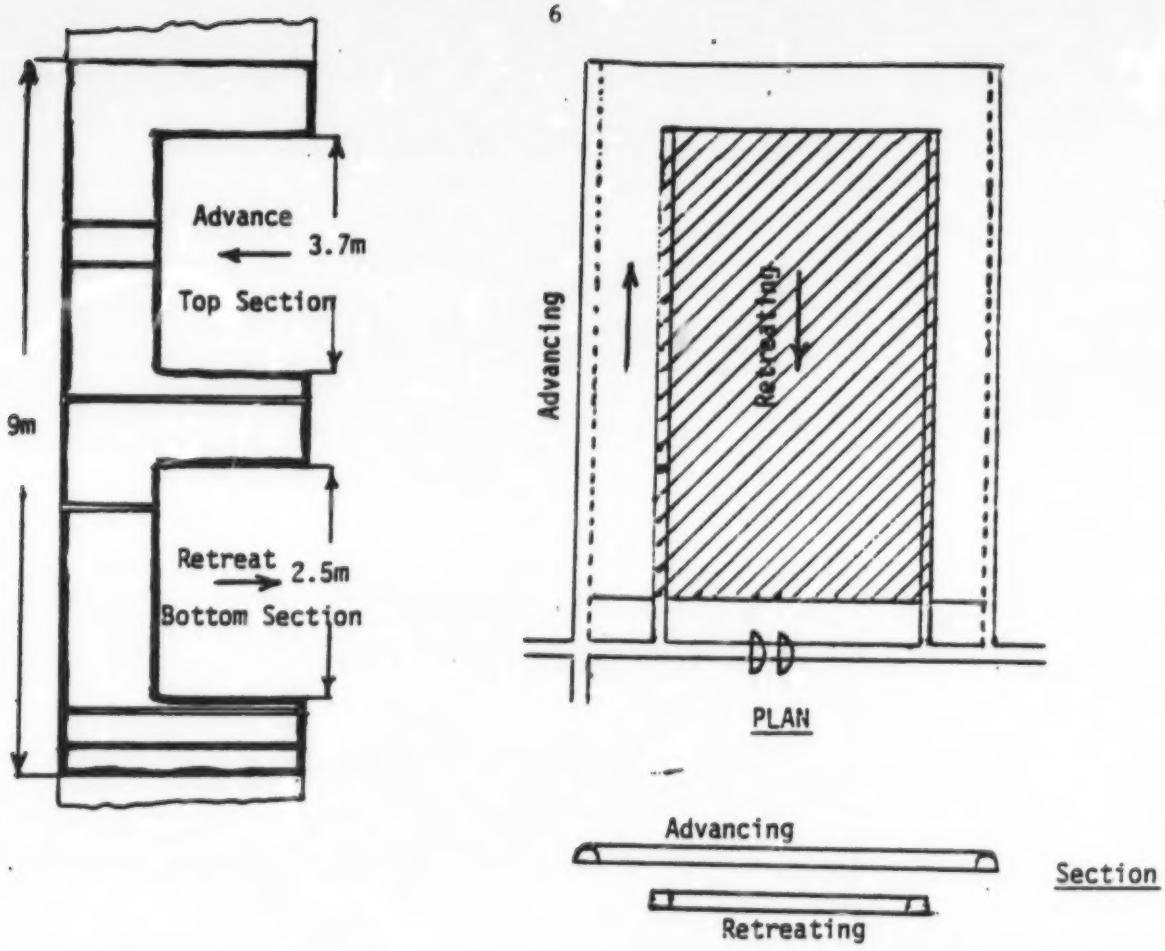

Fig. 5 - Thick seam working

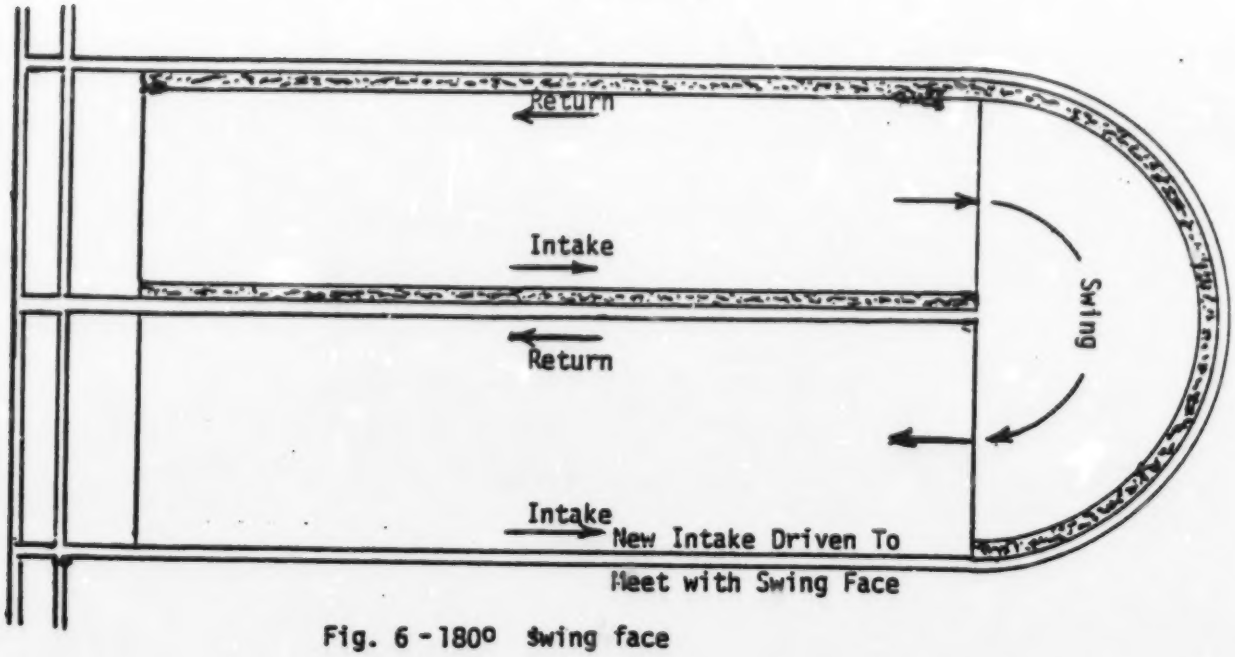

Fig. 6 - 180° Swing face

planning options. Such problems include spontaneous combustion, geological factors, existing workings both in seam and in superjacent and subjacent seams.

(i) FIG. 2 TWO PANEL SYSTEM - ONE RETREAT

This employs the re-use of one entry as a return and adopts the back airway system (which will be defined later) for the retreat panel. It provides for nearly total extraction of a two panel area. It is imperative to the successful adoption of such a system that the geological conditions will allow a realistic selection of an entry width that will secure both the roof beam and not promote floor heave.

(ii) FIG. 3 THREE PANEL SYSTEM - TWO RETREAT

This can only be employed in flatter seam gradients. Three panels can be extracted from the formation of face entries of which the two outer entries are driven at inseam height for the conveyor entries of retreat panels. A pillar of coal is left between subsequent layouts.

(iii) FIG. 4 Z SYSTEM

A requirement for this system is that the mine layout provides for the extraction of retreat panels from between two separate main entry systems in the mine. Retreat extraction is accomplished by driving one inseam entry for the gatebelt conveyor. The return airway entry is formed behind the face as extraction takes place. Construction of such an entry can be the limiting factor with respect to the speed of retreat of the panel.

(iv) FIG. 5 THICK SEAM EXTRACTION

Coal seams in the range of 7 m - 8 m thickness can be safely and effectively extracted with the present range of powered supports by the application of multilift systems and a combination of longwall advancing and retreating.

The first lift is taken as the upper slice with the face advancing in the upper section. The gates for retreat mining are driven in the lower section to a lesser panel length to ensure their positioning in a relaxed zone and, on completion of the extraction of the top slice by advancing methods, the lower slice is then retreated in a reverse direction to that of the upper advance panel.

The example just given is illustrated in Fig. 5 where the retreat panel goes back under a coal roof. A modification of the system has been used where the upper slice is taken, and a false roof is formed by laying continuous wire mesh panels on the floor of the upper slice. The lower slice is then retreated after a suitable time has elapsed to permit the caved roof of the upper slice to consolidate.

(v) FIG. 6 180° SWING FACE

This system might be considered as a variation of the two panelsystem. The idea of swinging a longwall advancing face through 180° at its terminal and then retreating back to the original starting line came from Germany. The system underwent a number of trials through a period during the late 60's and 70's and is now practised where conditions allow.

The problem with the system arises from the concentration of stress that is encountered at the main gate end of the face where the swing of the face pivots. This part of the face and its delivery onto the main gate will require, sometimes, daily changes in the support system to accommodate the conveyor transfer point from the face. It will also require high mean load support densities. Attention must also be paid to the gate that will be reused, and suitable provision must be made for its effective reinforcement during the life of the retreating panels.

A revival of interest in the system has emerged in the U.K. recently for the extraction of longwall panels in an irregular take in the Leicester coalfield.

On completion of a 180° swing, one such face then connected with a preformed gate that was already equipped with a gatebelt conveyor, and this then became the main gate for retreating the panel. This involved re-handing the A.F.C. for the face to run in an opposite direction for the purpose of retreating the face. This was a prudent decision because of the deterioration in the old main gate especially in the zone of the swing.

180° swing faces require:

1. Careful planning of the support system at the pivot point. This will entail daily modifications that will involve the taking out and the replacement of support segments during the swinging of the face.
2. Similar detailed planning of the cutting pattern on the face to accommodate the swing of the face line.

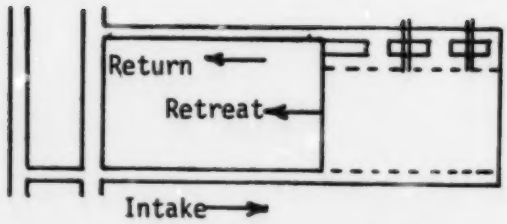

Fig. 7 - Back airway system

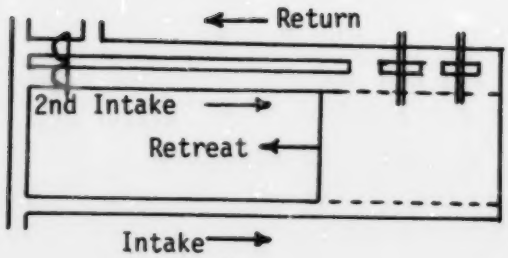

Fig. 8 - Back airway system
(Twin Intakes)

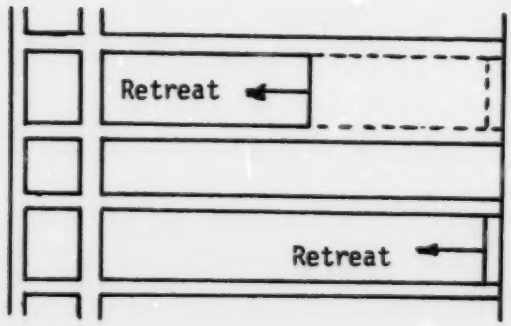

Fig. 9 - Unit panel retreat

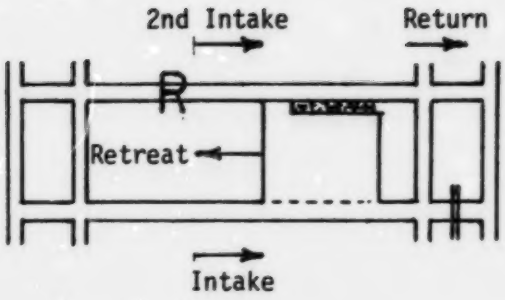

Fig. 10 - Bleeder roadway system

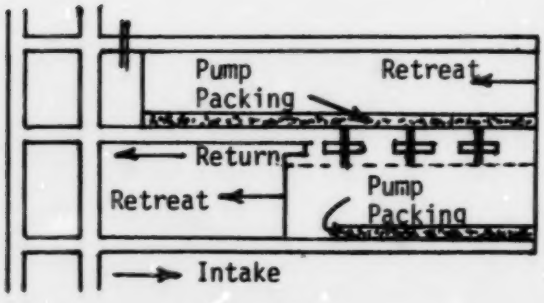

Fig. 11 - Successive adjacent retreat

PANEL LAYOUTS (RETREAT MINING)

As in the previous section, a number of retreat panel layouts are included below to give the reader an understanding of the various approaches that can be considered. Again, no attempt has been made to address site specific problems that may restrict mine planning options.

(i) FIG. 7 BACK AIRWAY SYSTEM

This system is used where gassy conditions prevail. To keep back the gas fringe, a small rib of coal of approximately 5m. width is left between the preformed entry and the top of the longwall panel. The rib is breached at regular intervals of between 15m - 55m. depending on conditions in the back airway.

(ii) FIG. 8 BACK AIRWAY SYSTEM (TWIN INTAKES)

This system is an extension of the system given in Figure 7, but provides for the additional needs of dust control in heavy dust conditions at the return end of the face. Regulation of the return side intake is required to approximately 25% of the total volume of air delivered to the face.

(iii) FIG. 9 UNIT PANEL RETREAT

This system provides the simplest approach to retreat mining with the protection of all roads by coal pillars. It is the most practised system in retreat longwall mining. Although illustrated for the sake of simplicity as a single entry system, it can be practised with multiple entries.

(iv) FIG. 10 BLEEDER ROADWAY SYSTEM (TWIN INTAKES)

This layout has a similar requirement on mains layout to operate as the Z system and provides for similar conditions as the back airway system. Before adopting such a system, it would be prudent to examine the potential for roof control problems at the return end of the face.

(v) FIG. 11 SUCCESSIVE ADJACENT RETREAT SYSTEM

This system permits total extraction of the area by the re-use of a preserved retreat entry. While development drivage is minimized, the re-use of a preserved retreat entry requires special support provision and frequently major roadway repair.

CONVERSION LONGWALL ADVANCING TO RETREAT AT CBDC

The Cape Breton Development Corporation is an established operator of both advance and retreat longwall mining.

In both systems of mining, barrier pillars are left between adjacent panels for the purposes of controlling seabed subsidence and avoiding panel interaction and consequent roadway deformation. The retreat system presently employed is that of unit panel retreat using single entries. The percentage extraction ratios are of an order of 65% - 70% for both longwall advancing and retreating. The percentage extraction ratio is defined by the size of the intervening barrier pillars and the lengths of the wallface. Because of depth and seabed subsidence considerations, panel widths in retreat mining have not yet exceeded 110 m. Panel widths in longwall advancing are up to 210 m.

Panel width and length are governing factors in decreasing the cost/tonne of developing panels. Panel width is currently under inventigation by a number of operators, mainly in the U.S.A., where panel widths up to 244m are now operating. Provided that an increase in panel width is not prejudicial to current productivity levels then longer panel widths will eventually become the norm. It should be noted that the trials in hand use almost nearly exclusively the heaviest duty equipment that is available.

Multiple entry development has been entrenched in the U.S.A. for a number of decades such that the term conventional mining applies to its practise. The development of longwall retreat panels using continuous miners with the provision of support by suspension roof bolts to support the entries has not involved departures from conventional mining practises. Some problems have arisen concerning the dimensioning and the yield of pillars to avoid severe stress interaction on the entry that flanks each successive face, and that is re-used for the return airway. An extensive use of cribbing is made in some cases to control and limit convergence in these returns, and some operators have experimented successfully in reducing the costs of such cribbing whilst maintaining mean support densities through the use of fibre reinforced concrete cribs in place of hardwood cribs.

Productive multiple entries systems at CBDC would almost certainly require a successful demonstration of effective support by suspension roof

bolting. If roof bolting cannot be demonstrated as an effective support system for entries in CBDC mines, then the cost/tonne of providing standing supports in multiple entries will make the cost/tonne of development greater than in the case of single entry development. Roof bolting has in certain circumstances been applied successfully in some rectangular gateroads in the deeper mines of the Ruhr coalfield.

An approximate empirical rule for the application of roof bolting for such circumstances has been that the length of the bolts that are used should be at least equal to half the width of the entry in which such bolts are used. The application of such a rule for an entry of 6 m width would necessitate bolts of at least 3 m in length. Bolts of such a length would involve the drilling of each hole with either 2 or 3 extension steels of increasing lengths, depending on the height of the entry. I would also necessitate the employment to insert the bolts in their respective holes of a bolt bender on the drilling machines, or the use of bolts with sleeve couplings.

The possibility of supporting entries in the development stages of longwall retreat mining by a suitable roof bolting system should not be dismissed out of hand.

Modifications or changes to mining methods such as the conversion from advancing to retreating longwall in operating mines is a difficult task that can have serious financial implications. Such a fundamental change needs careful consideration and planning to accomplish with minimal upset. Within the context of CBDC operations the author has examined the information available, discussed the subject with a number of colleagues and has given careful consideration to possible conversion mechanisms at Lingan Colliery as a test case.

With respect to Lingan Colliery it is suggested that a simple two panel system as shown on Figure 2, would be a logical framework in which to discuss the site specific conversion from advancing to retreating. Problem areas that must be addressed include:

a) support requirements in the advancing panel main gate since that gate will be used as the return from the retreat panel, (i.e. dual life gateroad),

b) development drivage and support of the retreat panel main gate with consideration of rectangular or trapezoidal cross section supported by posts and girders, roof bolts or a combination, and

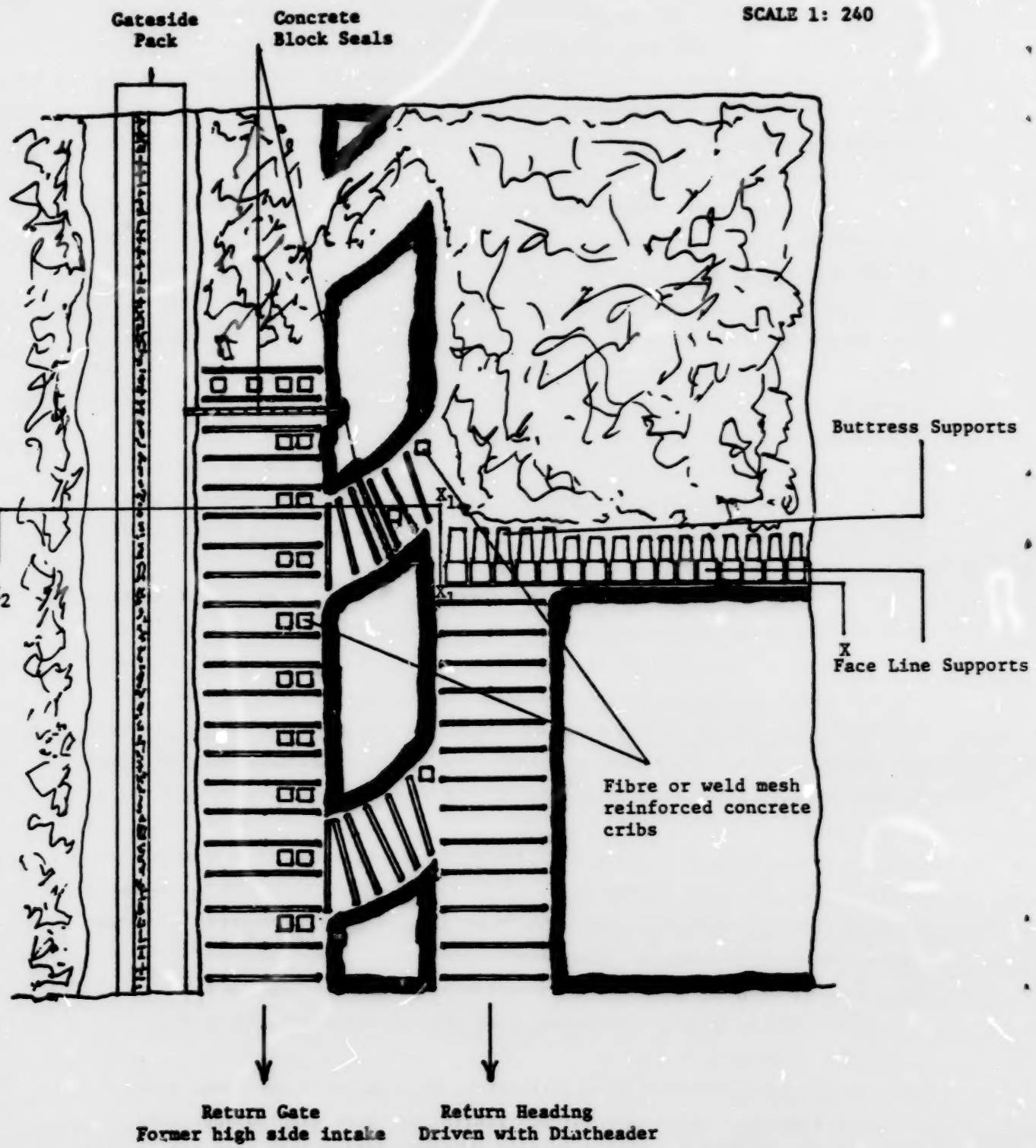

Fig. 12 - Planview re-use of intake main gate as return for lower side retreat face

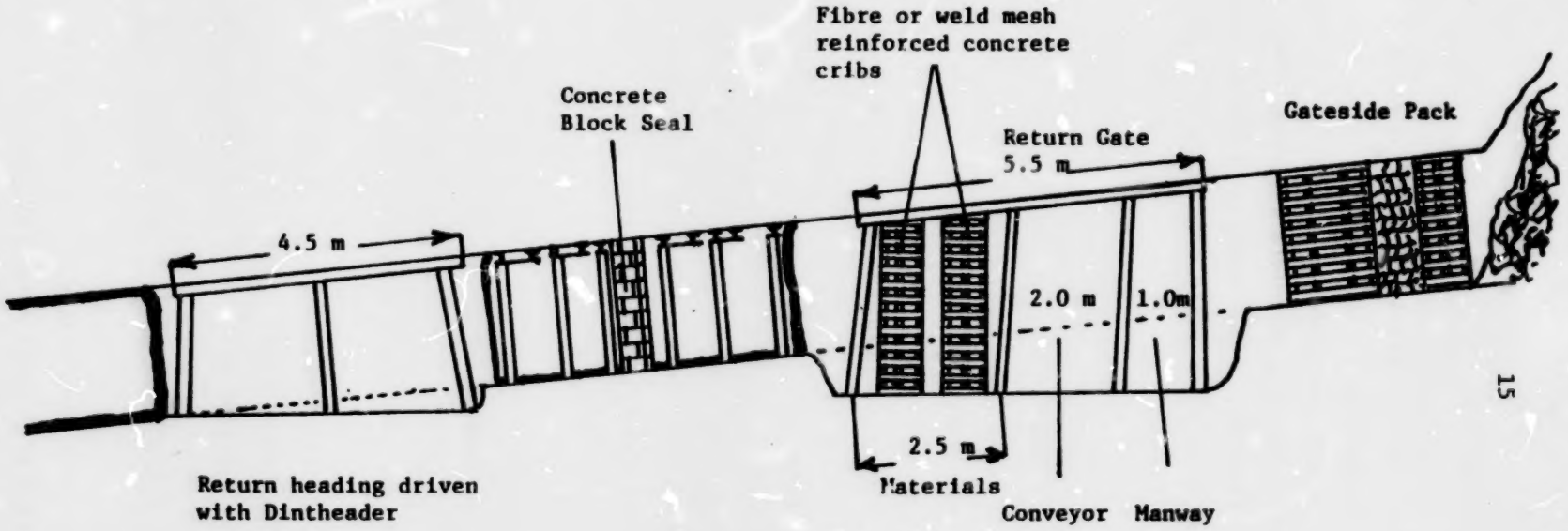

Fig. 13 - Section re-use of intake main gate as return for lower side retreat face
Section on line X-X_1-X_2 Fig. 12

c) selection of retreat panel width to permit rapid rates of face travel to minimize gate end problems.

Figures 12 & 13 are conceptual drawings intended to illustrate the use of the advancing panel main gate as a dual life gateroad. Note that this roadway is flat backed with a floor rip. This example is merely illustrative site specific factors may result in alternative concepts with a higher likelyhood of success.

CONCLUSIONS

Longwall retreat mining has been shown to be favourable when compared with advance longwall mining in many coalfields including the Sydney coalfield. Retreat longwall mining can improve resource recovery and lower production costs if adequate rates of gateroad development and acceptable entry conditions can be maintained.

Modifications or changes to mining methods in operating underground mines is a complex subject that requires careful review and consideration. On balance this review suggests that sufficient benefits could accrue from conversion to retreat longwall to justify the necessary investment of resources to consider this subject in detail.

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